# A & B IRRIGATION DISTRICT

# GROUNDWATER EVALUATION

**Prepared for:**

***A & B IRRIGATION DISTRICT***

Prepared by:

HDR Engineering, Inc.
and
Morrison Knudson

May 1998

## A & B IRRIGATION DISTRICT GROUNDWATER EVALUATION

## TABLE OF CONTENTS



## LIST OF TABLES

## LIST OF FIGURES

## ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| af or ac-ft | Acre-feet |
| cfs | Cubic feet per second |
| District | A & B Irrigation District |
| ESRP | Eastern Snake River Plain |
| HDR | HDR Engineering, Inc. |
| p. | Page |
| pp. | Pages |
| USBR | United States Bureau of Reclamation |
| USGS | United States Geological Survey |

# A & B IRRIGATION DISTRICT GROUNDWATER EVALUATION


## Summary

USGS data show that groundwater pumping from the ESRP Aquifer has increased by 113 percent from 1985 to 1990. This large increase in pumping has contributed to groundwater declinés in the Eastern Snake River Plains Aquifer (ESRP). The purpose of this study is to evaluate the nature and extent of the water level decline in A&B Irrigation District and it's impact on the District's capacity to supply water.

A&B Irrigation District supplies surface water, groundwater, and irrigation wastewater to about 81,500 acres, approximately 66,305 of which are served by groundwater and irrigation wastewater. Average annual water use by the district is approximately 260,100 acre-feet based on averages from 1960 to 1995. Using averages from the same years, about 22% or 57,200 acre-feet of water are pumped from the Snake River above Milner Dam to supply surface water to Unit A, and about 78% or 202,900 acre-feet of groundwater are pumped from wells in the ESRP Aquifer to supply Unit B.

Groundwater level declines in the district seriously threaten to reduce groundwater supply for the district. The District's records show that pumping capacity has declined steadily to a 1994 seasonal low capacity of 970 cfs. Thus, at low water levels, the District was able to supply only 88% of the 1100 cfs right.

Historical average annual costs incurred by A&B Irrigation District due to declining groundwater levels at an average rate 1.8 foot per year were estimated at $174,120 for the period of 1991-1995. Costs include:

- deepening and re-equipping wells at a average annual cost of $40,740.
- additional costs of $38,200 associated with transferring water from wells with extra capacity to supplement wells with reduced capacity or wells that have gone dry
- additional energy required to lift the groundwater which was $15,980 per year.
- lost assets including six deep wells that were abandoned with an annual average loss of $79,200.

Despite their efforts to mitigate for the declining water table, the pumping capacity continues to decline. Even if water levels continue to decline at a somewhat lower rate of 1 foot per year, projected annual costs to attempt to mitigate declines could initially be about $118,600. This sum does not include any costs to compensate shareholders for the loss of pumping capacity should mitigation prove unsuccessful.

With continuing declines, the costs will also increase as well deepening becomes less productive and more wells are abandoned. Thus, even with continued mitigation efforts, the District will slowly lose system capacity, which will result in an inability to meet the needs of the shareholders in the District.

# 1 INTRODUCTION

A & B Irrigation District operates and maintains the Northside Pumping Division of the Minidoka Project under a 1962 repayment contract with the Bureau of Reclamation (Figure 1). The District supplies surface water, groundwater and irrigation wastewater to about 81,500 acres approximately 66,305 of which are served by groundwater and irrigation wastewater. Average annual water use is approximately 260,100 acre-feet based on averages from 1960 to 1995. The District is divided into two units (Units A and B). Using the average from 1960 to 1995, about 22% or 57,200 acre-feet of water are pumped from the Snake River above Milner Dam to supply surface water to Unit A, and about 78% or 202,900 acre-feet of groundwater are pumped from wells in the Eastern Snake River Plain (ESRP) Aquifer to supply Unit B. There are over 80,000 additional acres irrigated by private groundwater wells located adjacent to the north, east, and west sides of the District.

# 2 PURPOSE AND SCOPE

Recently, groundwater levels within the District have been declining and seriously threaten to reduce the groundwater supply for the District. The purpose of this study is to evaluate the nature and extent of the water level decline in the District and its impact on the District's water supply, and to point out some potential reasons for the water level decline. The emphasis of this study is on local District groundwater issues, although the authors realize that the District represents only a small part of the ESRP aquifer and that a regional study is required for a complete understanding of the water level declines in the District. The material presented in this report documents the amount of the water level decline within the District, the costs the District has incurred to attempt to maintain its water supply, potential future reductions in capacity, and mitigation costs.

This study focuses on water use, the annual groundwater budget, spring discharge, the water table configuration, and water level trends in order to place the District groundwater problems in context with the regional system. The District groundwater concerns can be completely understood only within the context of the regional groundwater system, but such a study is beyond the scope of this task.

# 3 WATER USE

A visit was made to the A & B Irrigation District office in Rupert, Idaho, to review District records. The District has maintained detailed records of groundwater levels, pumping rates, well construction and maintenance, power consumption records, and operating costs. Much of the data is in computer spreadsheet files and is readily available in electronic format. The District made electronic and paper copies of selected data available for this project. As part of the site visit, District personnel hosted a field trip to visit the District's well installations and become familiar with the water distribution system.

The District supplies groundwater from a system of 177 wells. The capacity of individual wells varies from 1.7 cubic feet per second (cfs) to 12.0 cfs, averaging about 6 cfs. District records show that pumping capacity has declined steadily to a seasonal low capacity of 970 cfs. Thus, when groundwater levels were low, the District could only deliver 88% of the 1100 cfs right. The decline in pumping capacity is apparently due to the decline in groundwater levels, as described in this report.

Groundwater withdrawal by the District is only a small part of the total withdrawal from the ESRP aquifer. U.S. Geological Survey (USGS) water use data for 1985 and 1990, shown in Table 1, indicate that annual groundwater withdrawals for irrigation for the upper Snake River Basin increased 113% from 3.1 million acre-feet in 1985 to 6.6 million acre-feet in 1990. During the same period, surface water diversions decreased 2.7 million acre-feet (26 percent). This change in water use was accompanied by a decrease of 0.3 million acres (11 percent) of irrigated land.

The same water use data show that for Minidoka County, where the District is predominantly located, annual groundwater withdrawals increased 350,000 acre-feet (104 percent), while groundwater withdrawals by the District declined during the same period. The average annual groundwater withdrawal by the District for the period 1960 - 1995 was 202,900 acre-feet (Figure 2). This large increase in groundwater pumping has contributed to the decline in groundwater levels within the District and throughout most of the ESRP Aquifer.

**Table 1**
**Irrigation Withdrawals, 1985 and 1990**

| *Region* | *Ground water (acre-feet)* | | *Surface water (acre-feet)* | | *Irrigated area (acres)* | |
|---|---|---|---|---|---|---|
| | **1985** | **1990** | **1985** | **1990** | **1985** | **1990** |
| Upper Snake | 3,136,000 | 6,563,000 | 10,309,000 | 7,656,000 | 2,740,000 | 2,445,000 |
| Minidoka Co. | 338,000 | 688,000 | 512,000 | 423,000 | 182,000 | 163,000 |
| Source: USGS water use data reports. | | | | | | |

The large increase in groundwater use has resulted in a decline in groundwater levels indicating that recharge to the ESRP aquifer is now much less than the total combined discharge from wells and springs. When inflow is less than outflow, the shortfall must be made up from aquifer storage, and water levels will decline. The decline in outflow is accompanied by a change in the configuration of the groundwater table, generally a lowering of groundwater levels. The increase in groundwater use on the ESRP has resulted in both a decline in spring flow and a lowering of water levels, as described in Section 5.

## 4 GROUNDWATER BUDGET

Table 2 shows the water budget for the ESRP for 1980, as estimated by Garabedian (1992). The total groundwater recharge was estimated to be 8.1 million acre-feet. About 4.8 million acre-feet of that recharge was from the application of 7 million acre-feet of surface water irrigation on 1.4 million acres. Groundwater pumpage for 1980 (Bigelow and others, 1986) was about 1,760,000 acre-feet, used to irrigate about 930,000 acres. Garabedian estimated the amount of groundwater consumed (that is, not returned to the aquifer) was about 1,140,000 acre-feet. About 202,900 acre-feet of groundwater are pumped annually by the District.

Table 3 shows the losses and gains from surface water to the aquifer, as estimated by Kjelstrom (1992). The Snake River loses about 690,000 acre-feet per year to the aquifer along some river reaches. No water is lost from the river between Neeley and Minidoka. Losses from tributaries to the Snake River and from major canals contribute an additional 65,000 acre-feet per year. Spring discharge from the aquifer to the Snake River is about 6.4 million acre-feet, mostly to the reach from Blackfoot to Neeley and in the Thousand Springs area near Hagerman. Groundwater underflow from tributary valleys contributes 1,440,000 acre-feet (Garabedian, 1992).

The estimated groundwater budget for 1980 shows that outflow was greater than inflow, and there was a net loss of 160,000 acre-feet to groundwater in storage. Between 1985 and 1990, groundwater usage on the ESRP has about doubled, according to published USGS water use estimates. This increase in groundwater use has resulted in decrease in spring discharge and declining groundwater levels throughout the ESRP.

**Table 2**
**Groundwater Budget for Water Year 1980**

| *Recharge* | *Acre-feet* |
|---|---|
| Surface water irrigation | 4,840,000 |
| Tributary drainage-basin underflow | 1,440,000 |
| Direct precipitation | 700,000 |
| Snake River losses | 690,000 |
| Tributary stream and canal losses | 390,000 |
| Total | 8,060,000 |
| ***Discharge*** | |
| Snake River gains | 7,080,000 |
| Net Ground-water pumpage (consumed) | 1,140,000 |
| Total | 8,220,000 |
| ***Change*** | |
| Decrease in aquifer storage | 160,000 |
| Source: Garabedian, 1992 | |

**Table 3**
**Snake River Groundwater Losses and Gains from Groundwater for Water Year 1980**
*[From Kjelstrom, 1986]*

| *Reach* | *Loss (-) or gain (+)* | |
|---|---|---|
| | *(Cubic feet per second)* | *Acre-feet per year* |
| Heise to Lorenzo | -145 | -105,000 |
| Lorenzo to Lewisville | +289 | +209,000 |
| Lewisville to Shelley | -379 | -275,000 |
| Shelley to at Blackfoot | -153 | -111,000 |
| At Blackfoot to near Blackfoot | -270 | -196,000 |
| Near Blackfoot to Neeley | +2,620 | +1,902,000 |
| Neeley to Minidoka | +179 | +130,000 |
| Minidoka to Milner | +132 | +96,000 |
| Milner to Kimberly (north side) | +30 | +21,000 |
| Milner to Kimberly (south side) | +266 | +193,000 |
| Kimberly to Buhl (north side) | +1,112 | +807,000 |
| Kimberly to Buhl (south side) | +110 | +80,000 |
| Buhl to Hagerman (north side) | +3,456 | +2,509,000 |
| Buhl to Hagerman (south side) | +150 | +109,000 |
| Hagerman to King Hill | +1,412 | +1,025,000 |
| Total loss | -947 | -687,000 |
| Total gain | +9,756 | +7,081,000 |

## 5 SPRING DISCHARGE

Historically, surface water has been diverted from the Snake River to irrigate lands of the ESRP in amounts that far exceed crop consumption requirements and evaporation. That excess water recharged the aquifer beneath and caused the water table to rise above pre-irrigation conditions, increasing the discharge from springs along the Snake River. Kjelstrom (1986) showed that the average annual groundwater discharge from the north side of the Snake River from Milner to King Hill increased from about 4,300 cfs in 1910 to 6,800 cfs in 1951.

As available surface water supplies were fully developed, groundwater was used to supplement surface water and supply water to lands where surface water was not available. The increased use of groundwater, more efficient use of surface water, change in irrigation practices, and increase in irrigated area began to reverse the trend in rising spring discharge. Spring discharge has generally decreased since about 1951, except for a brief rise from about 1962 through 1975, which coincides with a period of increased precipitation. The rate of decline of spring flow increased during 1977, as drought reduced the supply of available surface water and groundwater was used to supplement and replace low surface water supplies. Kjelstrom estimated that spring flow had declined to about 6,000 cfs in 1980.

Recent estimates of total spring discharge are not available. But examination of individual spring discharge for major springs show significant declines in discharge since 1980. Box Canyon Spring (Figure 3) and Blue Lakes Spring (Figure 4) accounted for almost 580 cfs, or almost 10 percent of the total estimated spring discharge in 1980. Box Canyon Spring has declined about 100 cfs (26 percent) since 1950; Blue Lakes Spring has declined over 70 cfs (35 percent) during the same period. This decline in spring discharge is associated with a corresponding lowering of groundwater levels throughout the ESRP.

## 6 WATER TABLE CONFIGURATION

Records provided by the District included Spring and Fall groundwater level measurements made by the District. Additional groundwater level measurements were obtained from the USGS, including spring discharge, surface water diversions, and groundwater withdrawals.

Spring groundwater level measurements were used to construct water table contour maps for 1960 (Figure 5) and 1995 (Figure 6), the period for which District data were available. Spring groundwater levels were used for the maps because the fall groundwater data represent local drawdown in wells and are less representative of the regional water levels. The water table maps show that groundwater generally flows from east to west across the District. The groundwater gradient is relatively flat, about 5 feet/mile, except in the west end of the District, where the gradient abruptly steepens to about 25 feet/mile. This configuration is consistent with the configuration of the water table developed by the USGS for the ESRP (Lindholm, 1988).

The steep gradient on the west is probably due to a decrease in transmissivity or the capacity of the aquifer to transmit water. The lower capacity in the area of the steeper gradient is also evident in the capacity of the District wells. The capacity of the District wells was estimated by dividing the average pumping rate for each well by the amount of drawdown in the well during the pumping season. The specific capacity for wells in the area of the steep gradient was less than 450 gpm, compared with 450 gpm to 1200 gpm for in the area of the flatter gradient in the northeastern section of the District.

The configuration of the water table indicates that a significant quantity of groundwater flows across the District boundary from the east. The source of groundwater for the District comes mostly from recharge outside the District boundary. Small amounts of recharge occur within the District boundary from precipitation and from surface water irrigation in Unit A. Also, irrigation wastewater is used to recharge the aquifer to reduce water table declines to the extent possible.

## 7 WATER LEVEL TRENDS

The shape of the water table has changed little since irrigation began, although the elevation of the water table has declined. Figure 7 shows the decline in the water table between 1960 and 1995. The amount of the decline is uniformly distributed within the district, averaging about 18 feet.

Groundwater levels of the ESRP aquifer vary both seasonally and in the long term. Seasonal variations are due in part to the difference in precipitation between winter and summer. Long-term variations are due to gradual changes in climate, punctuated by years of extreme rainfall or drought. But most of the variation is due to surface and groundwater irrigation. Hydrographs for selected wells within the District (see locations on Figure 8) are shown in Figures 9 through 18. Both the seasonal and long-term change in water levels are shown for U.S. Bureau of Reclamation (USBR) Wells USBR5 and USBR3 and USGS Wells 4S24E06BBC1 and 8S24E31DAC1. Only the water table for spring is shown for the rest of the wells.

Seasonal fluctuations in District wells average about 9 feet. Surface water irrigation, groundwater pumping, and seasonal changes in precipitation account for most of the short-term fluctuation. These seasonal changes are included on the long-term changes. Changes in irrigation practice, irrigated area, and climate changes influence the long-term fluctuations.

Groundwater levels in the District declined in the early 1960s, mostly because of a short period of lower-than-normal precipitation, and then reached a peak again in about 1973. During the declining period, the District rectified all 177 wells. Another period of low precipitation then caused water levels to decline again until about 1983. This period included a severe drought during 1977, which prompted many irrigators to supplement their water supply with groundwater. This increase in groundwater usage increased the rate of water level decline. Groundwater levels rose again until about 1988, when the longest and most rapid period of decline in the District began. These wet and dry periods are also evident in the discharge of the Snake River at King Hill.

During the irrigation season, most of the discharge measured at King Hill (Figure 19) is spring discharge from the ESRP aquifer north of the Snake River. In dry years almost all surface water is diverted upstream for irrigation, and almost no flow passes Milner Dam upstream. At such times, the spring discharge makes up a greater portion of the total flow. During wet years, more surface water is available, and surplus water not diverted for irrigation is released past Milner Dam. So the discharge at King Hill is a good indicator of both the relative amount of water available for irrigation and the amount of recharge to the aquifer. The fluctuations in the discharge at King Hill generally follow the fluctuations in the groundwater levels.

Groundwater levels have been declining at an average rate of about 1.8 feet per year since 1988. This decline is at least partly due to the large increase in groundwater use reported in the USGS water use reports for 1985 and 1990, which have been mentioned earlier. During this same period, the District's groundwater usage remained fairly constant.

Declining water levels are not limited to the area of the District. Similar water level declines have been measured in other areas of the ESRP Aquifer as shown by the USGS Well 04-S24E-06bbc1 (Figure 11). Although this well is located about 30 miles north of Rupert, away from any major influences such as groundwater pumping or surface water irrigation, it still shows significant declines in water level. The declines in this well are indicative of regional water level declines due to changes in precipitation, increased groundwater pumping, increased irrigated area, and decreasing surface water diversions throughout the ESRP.

## 8 DISTRICT MITIGATION EFFORTS

This section describes the increased costs experienced by the District in an attempt to mitigate the effect of a declining water table. In addition to Mitigation costs, there are other costs directly associated with pumping groundwater which involve the operation and maintenance of booster pumping stations to distribute groundwater once it is on the surface.

Historically the District has experienced certain annual costs associated with the pumping of groundwater. These costs were experienced while the historic groundwater fluctuations were within an acceptable range, and did not require modification to either the well or the pumping units. The costs generally include the cost of the electricity, the repair or replacement of pump units, the maintenance of groundwater pumping units and electrical systems and the occasional replacement of a well that would fail. The typical maintenance costs were those experienced with the repair of pumping equipment due to normal wear and tear. The largest costs were generally the energy costs associated with the volume of groundwater pumped each year.

The annual volumes pumped each year are shown on Figure 2. The annual pumpage ranges from 164,500 to 227,000 acre-feet per year for the period 1960 to 1995. Table 4 summarizes the annual energy costs, including conveyance losses, the District has incurred during the 10-year period 1986 to 1995.

**Table 4**
**Annual Energy Costs**
**Period 1986 - 1995**

| | *Ann. Metered* | *Loss* | *Factors* | *kWHr* | *Rate* | *Annual* |
|---|---|---|---|---|---|---|
| *Year* | *Energy (kWHr)* | *BCF* | *System* | *Total* | *(mills)* | *Costs* |
| 1986 | 73,044,709.00 | 1.05 | 1.02 | 78,230,883.00 | 10.63 | $831,595 |
| 1987 | 83,334,369.00 | 1.05 | 1.02 | 89,251,109.00 | 10.63 | $948,740 |
| 1988 | 81,072,882.00 | 1.05 | 1.02 | 86,829,056.00 | 10.63 | $922,995 |
| 1989 | 80,565,574.00 | 1.077 | 1.029 | 89,258,428.00 | 10.63 | $949,105 |
| 1990 | 88,484,340.00 | 1.077 | 1.029 | 98,061,265.00 | 10.63 | $1,042,390 |
| 1991 | 77,171,340.00 | 1.077 | 1.029 | 85,523,616.00 | 10.63 | $909,115 |
| 1992 | 91,106,299.00 | 1.077 | 1.029 | 100,967,007.00 | 15.05 | $1,519,550 |
| 1993 | 74,191,212.00 | 1.077 | 1.029 | 82,221,149.00 | 15.05 | $1,237,430 |
| 1994 | 86,411,452.00 | 1.077 | 1.029 | 95,764,022.00 | 15.05 | $1,441,250 |
| 1995 | 69,856,028.00 | 1.077 | 1.029 | 77,416,755.00 | 15.05 | $1,165,125 |

As stated earlier, the groundwater levels have been gradually declining for a number of years but has increased to an alarming rate since about 1988. As shown on Figure 7, the decline of groundwater surface elevation from 1960 to 1995 ranged from 11-feet to 19-feet. This decline in groundwater table has produced a corresponding increase in the annual electrical costs, as a result of a higher average pumping lift. Additionally, the District has experienced other costs related to the declining groundwater levels which include, deepening existing wells to maintain production capacity, lowering the bowls of pump units to assure proper submergence, modifying pumping units (changing bowls units, adding additional horsepower, etc.). These costs, as estimated by the District, totaled $203,700 for the period 1991-1995, which produces an average annual cost of $40,740.

In addition to the costs incurred to attempt to mitigate for the declining water table, the district has had to abandon 6 deep wells between 1991 and 1995. Assuming a replacement well would be 600 feet deep and costs approximately $110.00 per foot to drill, each well would cost $66,000. The loss of the wells over the period of 1991 to 1995 would be $396,000, or $79,200 annually.

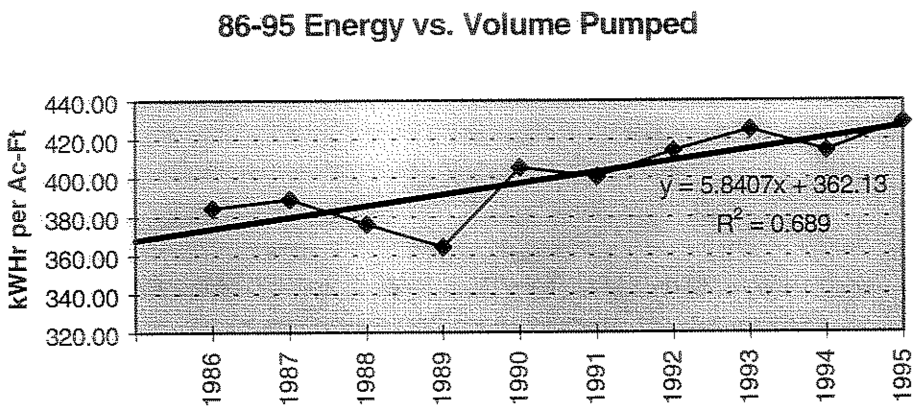
The District experienced additional costs associated with the decline of the groundwater levels due to the loss of these wells and loss of production from other wells. These costs involved the construction of new booster pumping stations, pipelines, and equipment to transport water from wells with reduced production rates or that went dry as a resulting of the declining groundwater, to areas where well production was sufficient to provide additional water supply. This network of connecting pipelines creates additional operational and maintenance cost for the District. Estimates of these costs provided by the District for the period 1991- 1995 were $191,000 or $38,200 annually.

An estimate was made of the additional energy required to lift the groundwater as a result of the declining water table. Table 5 shows the amount of energy required to lift an acre-foot of groundwater. If the water table would have remained relatively static during this period there would have been only a small variance in the unitized energy requirements. Increases in the unitized energy values reflect declining groundwater levels and corresponding increases in the pumping lifts.

**Table 5**
**Unitized Energy of Pumping from Deep Wells**
**Period 1986-1995**

| *Year* | *Annual Volume Pumped (Ac-Ft)* | *Annual Metered Energy Used (kWHr)* | *Unitized Energy (kWHr / Ac-Ft)* |
|---|---|---|---|
| 1986 | 190,056 | 73,044,709 | 384.3 |
| 1987 | 214,189 | 83,334,369 | 389.1 |
| 1988 | 215,598 | 81,072,882 | 376.0 |
| 1989 | 221,197 | 80,565,574 | 364.2 |
| 1990 | 218,409 | 88,484,340 | 405.1 |
| 1991 | 192,683 | 77,171,151 | 400.5 |
| 1992 | 220,124 | 91,106,299 | 413.9 |
| 1993 | 174,605 | 74,191,212 | 424.9 |
| 1994 | 208,689 | 86,411,452 | 414.1 |
| 1995 | 162,918 | 69,856,028 | 428.8 |

Using the unitized energy values from the table, a trendline was developed using a regression analysis method to develop the "best fit" for the data points shown. The trendline method is preferred over use of the individual annual data points with their variations. A relatively high correlation coefficient (0.689) suggests statistical confidence in the line shown on the figure below.




Development of the trendline for the unitized energy allowed for an estimation to be made of the increased energy required to lift groundwater as a result of a declining groundwater table that has been experienced by the District during the period of 1986-1995. Using the trendline, the change in energy required to lift an acre-foot of water varied from a value of 367.9 kWHr in 1986 to 420.5 kWHr in 1995, a difference of 52.6 kWHr per acre-feet for the period shown, which equates to 5.26 kWHr per acre-foot per year. The average annual volume pumped during this same period was 201,850 acre-feet, which required an additional (201,850 x 5.266=) 1,061,730 kWHr per year. Using the Districts current mill rate of 15.05 mills per kWHr, the average annual increase in pumping costs total $15,980. The average annual decline of the groundwater during this period averaged 1.8 feet per year.

The estimates of these additional costs or losses the District has experienced as a result of the decline of groundwater levels are summarized in Table 6. These estimates used the costs for the period 1991-1995 as representative of the entire period since 1988, when the decline increased to a rate of about 1.8 feet per year.

**Table 6**
**Increased Costs Resulting From Declining Aquifer Levels**
**Period 1991 - 1995**

| *Category* | *Annual Costs* |
|---|---|
| Deepening Wells, re-equipping, etc. * | $40,740 |
| Abandon and Replace Wells | $79,200 |
| New Pumping Stations, Pipelines, etc. * | $38,200 |
| Compute Add'l Energy Costs | $15,980 |
| Total | $174,120 |
| * Source A&B I.D. Manager | |

## 9 Projected Mitigation Costs

If groundwater levels continue to decline, wells will need to be deepened, and new wells will need to be constructed to maintain the production capacity needed by the District. Over the period of 1989 to 1994 decline was 9 feet or 1.8 feet per year. To assess projected future costs, a conservative lower decline of 1 foot per year was assumed. Future rates of decline will depend on ESRP Aquifer recharge rates and volumes of water pumped.

Groundwater level declines will produce a loss in production capacity caused by a decline in well efficiency and pumping plant capacity as the pumping head increases. Most pumps are designed to operate efficiently within a range of head. As the head increases, the capacity of the pump decreases. As the water level approaches the bottom of the well, the production capacity of the well approaches zero. Actually, because the pump cannot be placed directly on the bottom of the well, production ceases at some point above the bottom of the well, when the water level is below the pump intake.

The loss in production capacity with a decline in water level can be estimated by straight line interpolation between the current water level (100 percent capacity) and some water level near the bottom of the well (0 percent capacity). Although this is a simple approach to estimating the decline in production, it provides a rough estimate of future production losses. Table 7 shows the approximate loss in production capacity at the end of each 10-year period assuming a decline of 1 foot per year, which is conservative in comparison to the 1.8 feet per year declines previously observed. A point 10 feet above the bottom of the well was assumed to account for placement of the pump and drawdown. Without replacement or deepening of wells, production capacity would drop approximately 14 percent within the next 10 years (assuming a linear decline in pumping capacity).

District records show that total well production decreased 76 cfs from 1989 to 1994. This coincides with decline in water levels of about 6.9 feet (Figure 20). The observed decline in capacity of about 7 percent in 5 years or 14 percent in 10 years confirms the estimates shown in Table 7.

Table 7 also shows the percentage of wells that would go dry as water levels decline. For example, the well bottom elevations of 20 percent of the wells were less than 50 feet below the water table in 1995. This means that if water-levels decline 1 foot per year, 20 percent of the wells will be dry in 50 years.

**Table 7**
**Reduction in Pumping Capacity Due to Decline in Water Level**

| *Submerged well length (feet)* | *Proportion of wells in 1995[1] with submerged length less than column 1 value* | *Cumulative reduction in pumping capacity[2] (Years)* | | | | |
|---|---|---|---|---|---|---|
| | | *10 years* | *20 years* | *30 years* | *40 years* | *50 years* |
| 10 | 1% | 1.25% | 1.25% | 1.25% | 1.25% | 1.25% |
| 30 | 4% | 0.83% | 1.67% | 2.50% | 2.50% | 2.50% |
| 50 | 20% | 3.25% | 6.50% | 9.75% | 13.00% | 16.25% |
| 70 | 50% | 4.29% | 8.57% | 12.86% | 17.14% | 21.43% |
| 90 | 66% | 1.74% | 3.47% | 5.21% | 6.94% | 8.68% |
| 110 | 76% | 0.91% | 1.82% | 2.73% | 3.64% | 4.55% |
| 130 | 84% | 0.67% | 1.35% | 2.02% | 2.69% | 3.37% |
| 150 | 87% | 0.17% | 0.33% | 0.50% | 0.67% | 0.83% |
| 170 | 90% | 0.18% | 0.37% | 0.55% | 0.74% | 0.92% |
| 190 | 93% | 0.16% | 0.33% | 0.49% | 0.66% | 0.82% |
| 210 | 95% | 0.09% | 0.18% | 0.27% | 0.36% | 0.45% |
| 230 | 97% | 0.08% | 0.16% | 0.24% | 0.33% | 0.41% |
| 250 | 97% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| 270 | 98% | 0.02% | 0.05% | 0.07% | 0.09% | 0.12% |
| 290 | 100% | 0.09% | 0.17% | 0.26% | 0.34% | 0.43% |
| Total | | 14% | 26% | 39% | 50% | 62% |

[1] Assuming 10-foot drawdown during pumping.
[2] Assuming a decline in water level of 1 foot per year.

In addition to a loss in production capacity as water levels decline, it is assumed the District will continue to incur costs comparable to previous years. Assuming a decline in the water level of 1 foot per year rather than the historical average of 1.8 foot per year, the cost for deepening and re-equipping wells will be $22,600, and the cost for new pumping stations, pipelines, etc. will be $21,200. With the lower water level decline of 1 foot per year, approximately 1 well per year will need to be replaced at $66,000. Finally, due to the decline, the pumping lift will increase and consequently energy consumption and energy costs will increase. Assuming an estimated energy cost of 15.05 mills per kWHr, an average pumping volume of 201,850 acre feet, an increase of 2.9 kWHr/acre foot/foot of decline, and an annual water level decline of 1 foot, District energy costs would increase $8,800 per year. The projected annual costs that the district might anticipate due to the declining water table are shown on Table 8.

**Table 8**
**Projected Annual Costs Due to a 1-ft per year Decline in Water Levels**

| *Category* | *Projected Annual Costs* |
|---|---|
| Deepening Wells, re-equipping, etc. | $22,600 |
| Loss of Production Capacity | **Unknown** |
| New Pumping Stations, pipelines, etc, | $21,200 |
| Abandon and Replace Wells (assume 1/yr) | $66,000 |
| Additional Energy Costs | $8,800 |
| Average Annual Costs | $118,600 |

With continuing ESRB Aquifer water level declines, the costs incurred by the District will continue and will likely increase as well deepening and pump lowering becomes less productive and more wells are abandoned. Thus, even with continued mitigation efforts, the District will slowly lose system capacity, which will result in an inability to meet the needs of the shareholders in the District.

## 10 REFERENCES


A&B Irrigation District, 1995, *General information*: Rupert, Idaho, unpublished report, p. 1.

– 1995, *Annual Fall Pump Report, Part 1, System Performance During Peak Period*: Rupert, Idaho, unpublished report, 5 pp.

– 1995, *Annual Fall Pump Report, Part 2, Hydrologic Data of Individual Wells*: Rupert, Idaho, unpublished report, 6 pp.

– 1995, *Annual Fall Pump Report, Part 3, Physical Data on Individual Wells*: Rupert, Idaho, unpublished report, 4 pp.

– 1995, Comparison of Total cfs Capacity, 1963-1994: Rupert, Idaho, unpublished report.

– 1995, Spring and Fall Static Depth to Water, 1959-1995: Rupert, Idaho, unpublished report.

Bigelow, B.B., Goodell, S.A., and Newton. G.D., 1986, *Water withdrawn for Irrigation in 1980 on the Snake River Plain, Idaho and Eastern Oregon*: U.S. Geological Survey Hydrologic Investigations Atlas HA-690, scale 1:1,000,000, 2 sheets.

Crosthwaite, E.G. and Scott, R.C., 1956, *Groundwater in the North Side Pumping Division Minidoka Project, Minidoka County, Idaho*: U.S. Geological Survey Circular 371, 20 pp.

Garabedian, S.P., 1992, *Hydrology and Digital Simulation of the Regional Aquifer System, Eastern Snake River Plain, Idaho:* USGS Professional Paper 1480-F, 102 pp.

Goodell, S.A., 1988, *Water Use on the Snake River Plain, Idaho and Eastern Oregon*: U.S. Geological Survey Professional Paper 1408-E, 51 pp.

Jones, M.L. and Tungate, A.M., 1989, *Hydrographs of Water Levels in Observation Wells in Idaho, 1982-88*: U.S. Geological Survey Open-File Report 89-232, 330 pp.

Kjelstrom, L.C., Stone, M.J., and Harenberg, W.A., 1995, *Statistical Summaries of Streamflow Data for Selected Gaging Stations in Idaho and Western Wyoming through September 1990*: U.S. Geological Survey Water-Resources Investigations Report 94-4070 94 pp.

Kjelstrom, L.C.,1986, *Flow Characteristics of the Snake River and Water Budget for the Snake River Plain, Idaho and Eastern Oregon*: U.S. Geological Survey Hydrologic Investigations Atlas HA-680, scale 1:1,000,000, 2 sheets.

– 1988, *Estimates of Gains and Losses for Reservoirs on the Snake River from Blackfoot to Milner, Idaho, for Selected Periods, 1912 to 1983*: U.S. Geological Survey Water-Resources Investigations Report, 87-4063, p. 62.

– 1995, *Statistical Summaries of Streamflow Data for Selected Gaging Stations in Idaho and Western Wyoming through September 1990*: U.S. Geological Survey Water Resources Investigations Report 94-4069, 534 pp.

Lindholm, G.F. and Goodell, S.A., 1986, *Irrigated Acreage and Other Land Uses on the Snake River Plain, Idaho and Eastern Oregon*: U.S. Geological Survey Hydrologic Investigations Atlas HA-691, scale 1:1,000,000.

Lindholm, G.F., Garabedian, S.P., Newton, G.D., and Whitehead, R.L., 1988, *Configuration of the Water Table and Depth to Water, Spring 1980, Water-level Fluctuations, and Water Movement in the Snake River Plain Regional Aquifer System, Idaho and Eastern Oregon*: U.S. Geological Survey Hydrologic Investigations Atlas HA-703, scale 1:500,000.

Newton, G.D., 1978, *Application of a Simulation Model to the Snake Plain Aquifer*: Moscow, University of Idaho, unpublished Ms. 82 pp.

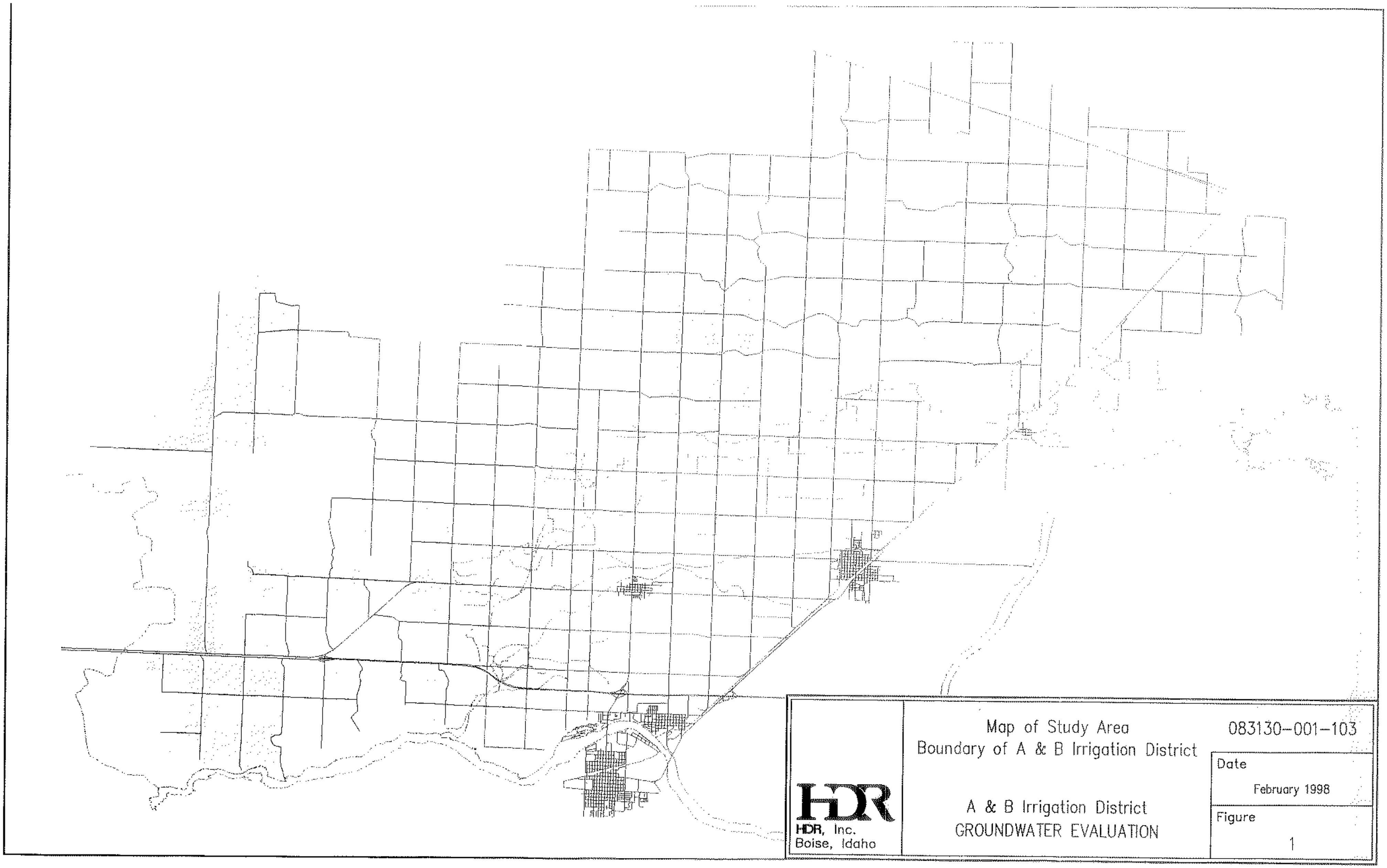
Solley, W.B., Pierce, R.R., and Perlman, H.A., 1993, *Estimated Use of Water in the United States in 1990*: U.S. Geological Survey Circular 1081.

Walton, W.C., 1959, *Results of Test Drilling and Aquifer Tests in Jerome, Lincoln, and Minidoka Counties, Idaho*: U.S. Geological Survey Open-File Report, 26 pp.

Whitehead, R.L., 1986, *Geohydrologic Framework of the Snake River Plain, Idaho and Eastern Oregon*: U.S. Geological Survey Hydrologic Investigations Atlas HA-681, scale 1:1,000,000, 3 sheets.

Young, N.C., and Ralston, D.R., 1971, *Reasonable Pumping Lifts for Idaho*: Idaho Department of Reclamation Water Information Bulletin 21, 38 pp.

# FIGURES


Map of Study Area
Boundary of A & B Irrigation District
083130-001-103
Date
February 1998
HDR, Inc.
Boise, Idaho
A & B Irrigation District
GROUNDWATER EVALUATION
Figure
1

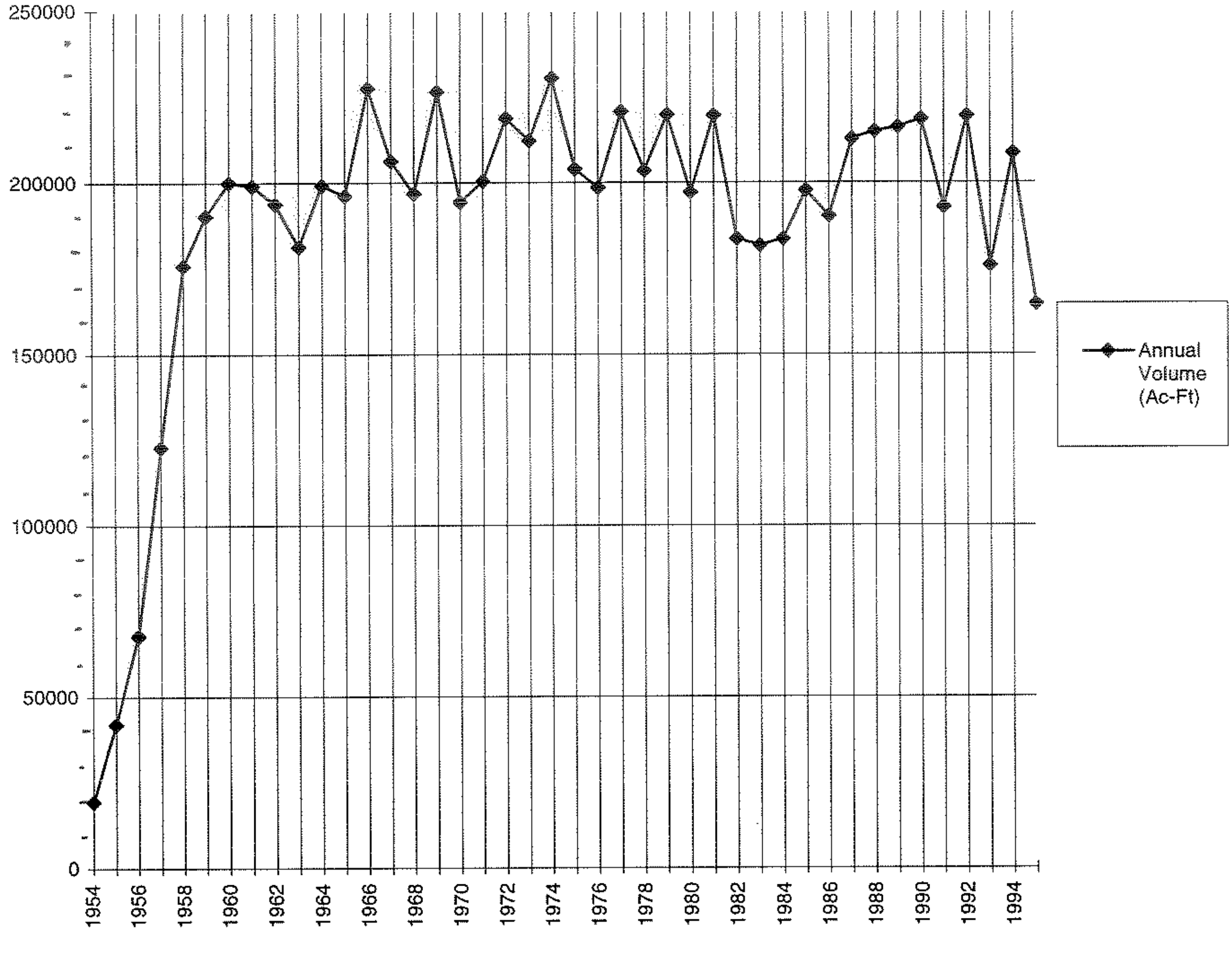



**Figure 2, A&B Irrigation District ESRP Groundwater Pumpage, 1954-1995**

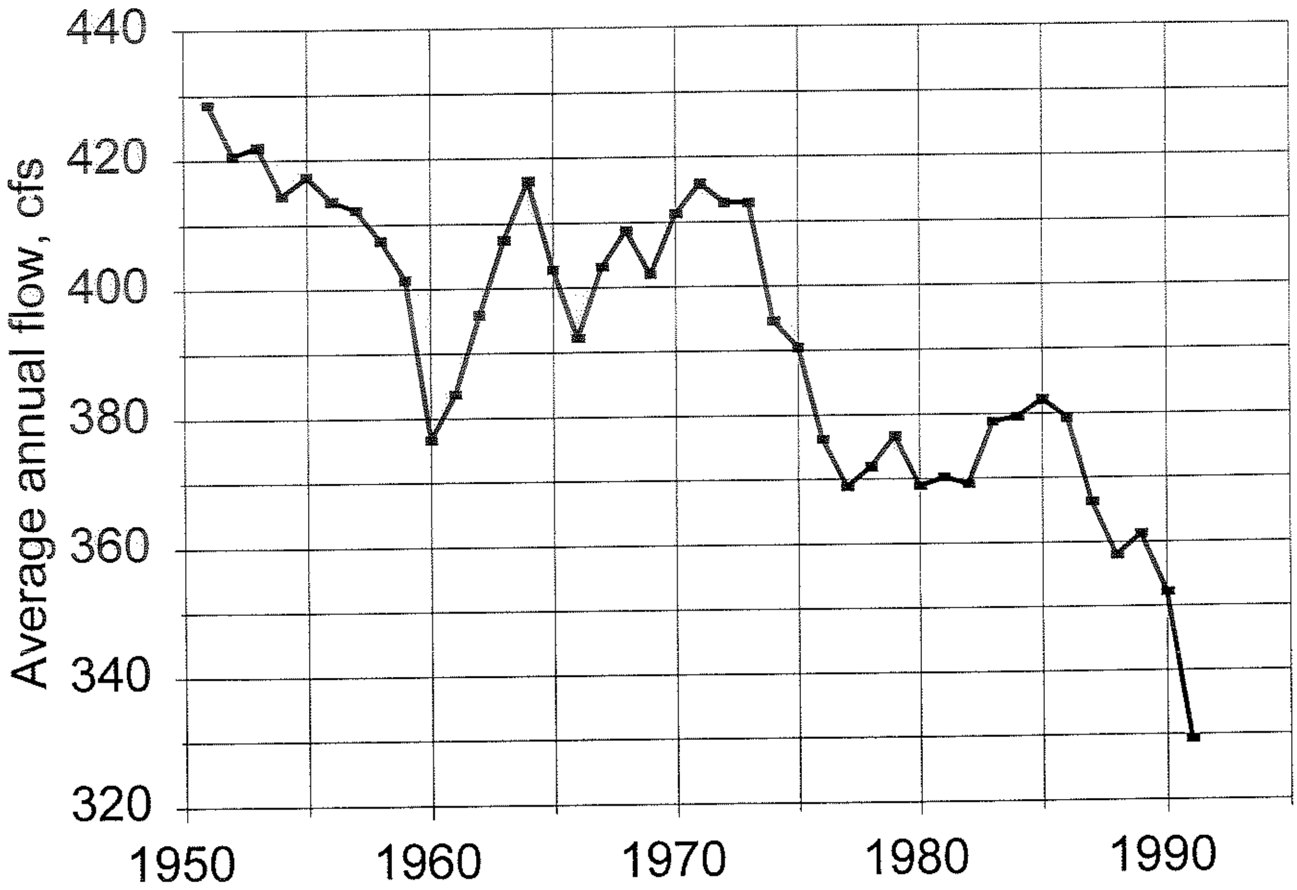



Figure 3. Hydrograph of Box Canyon Spring, 1951 to 1993

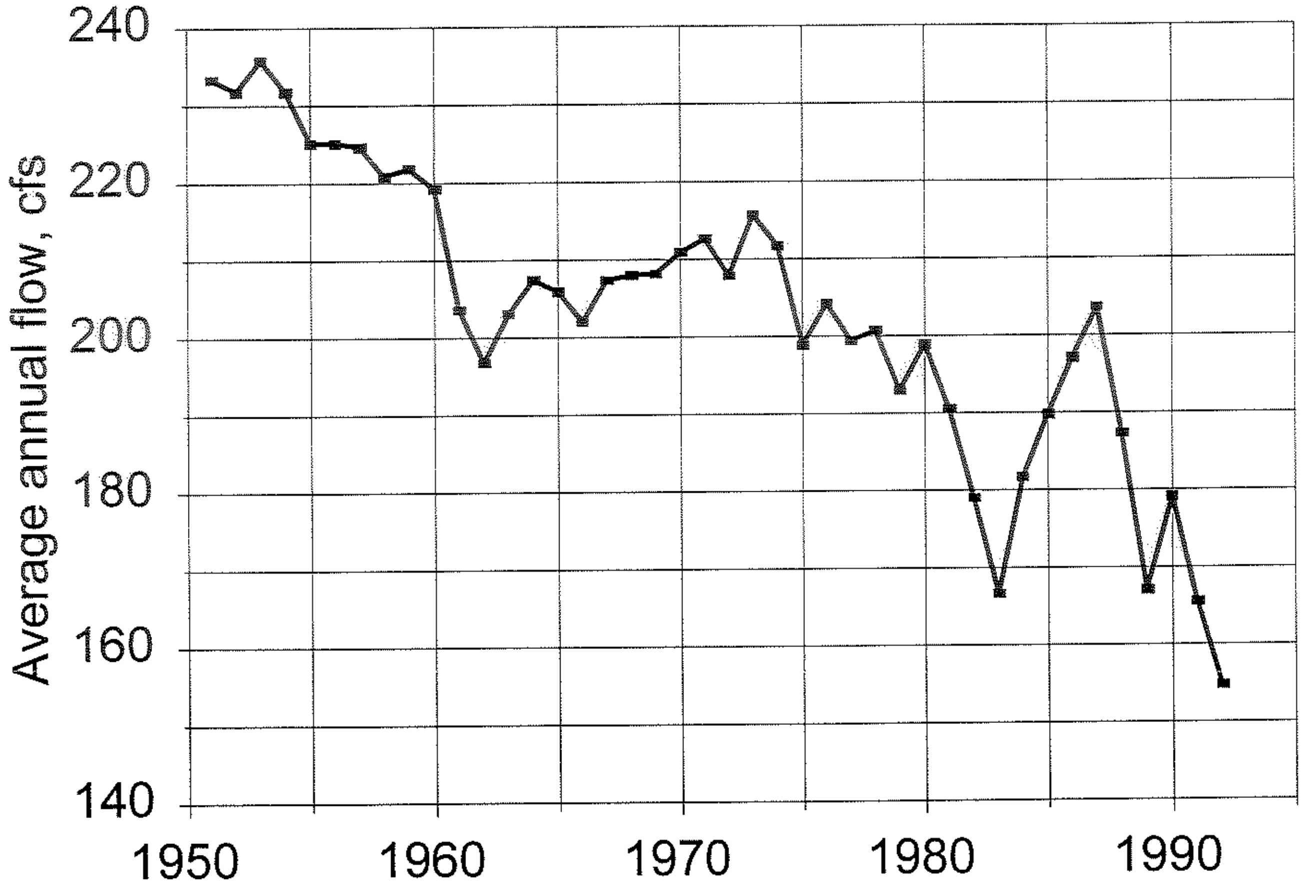
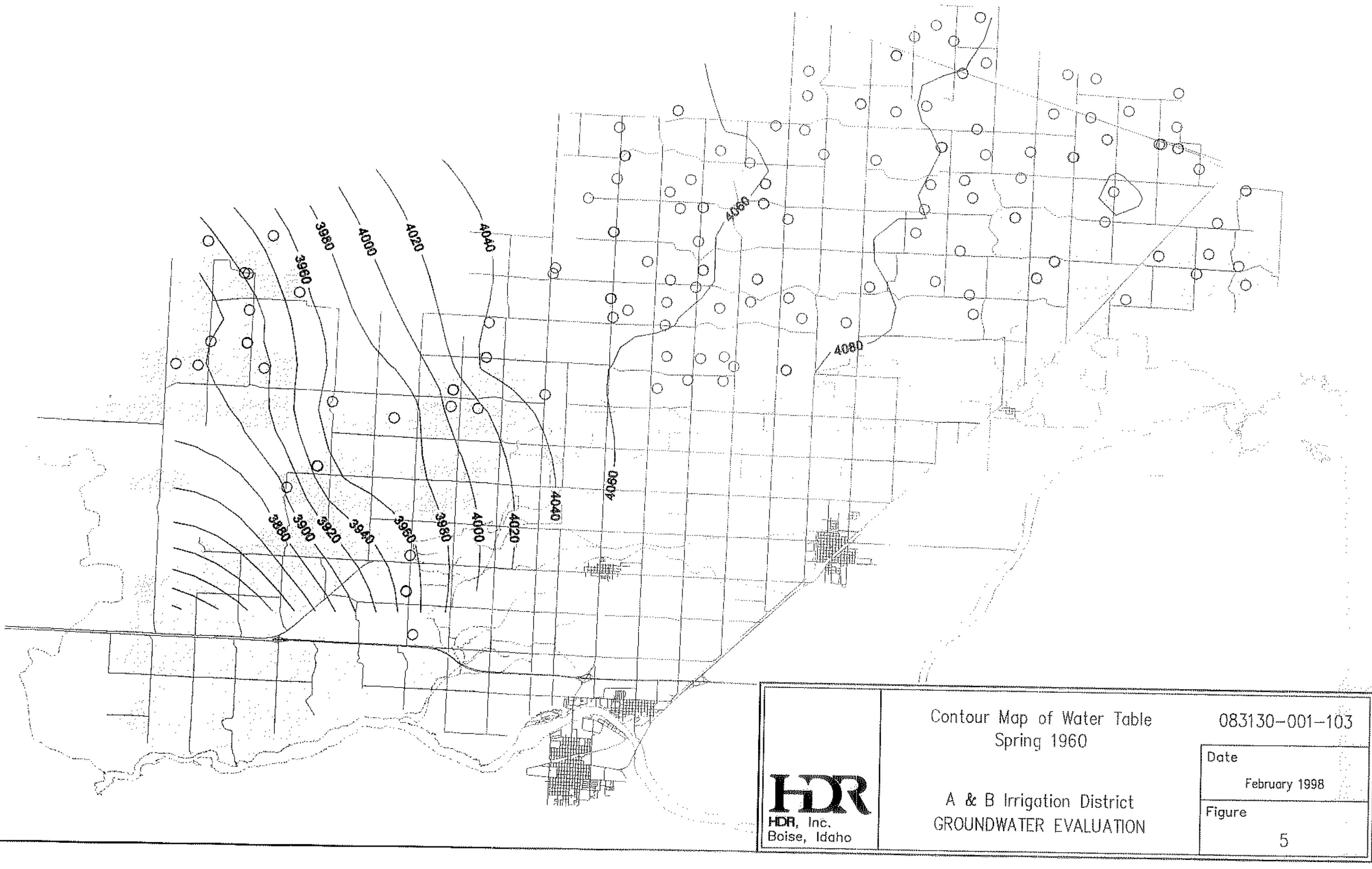
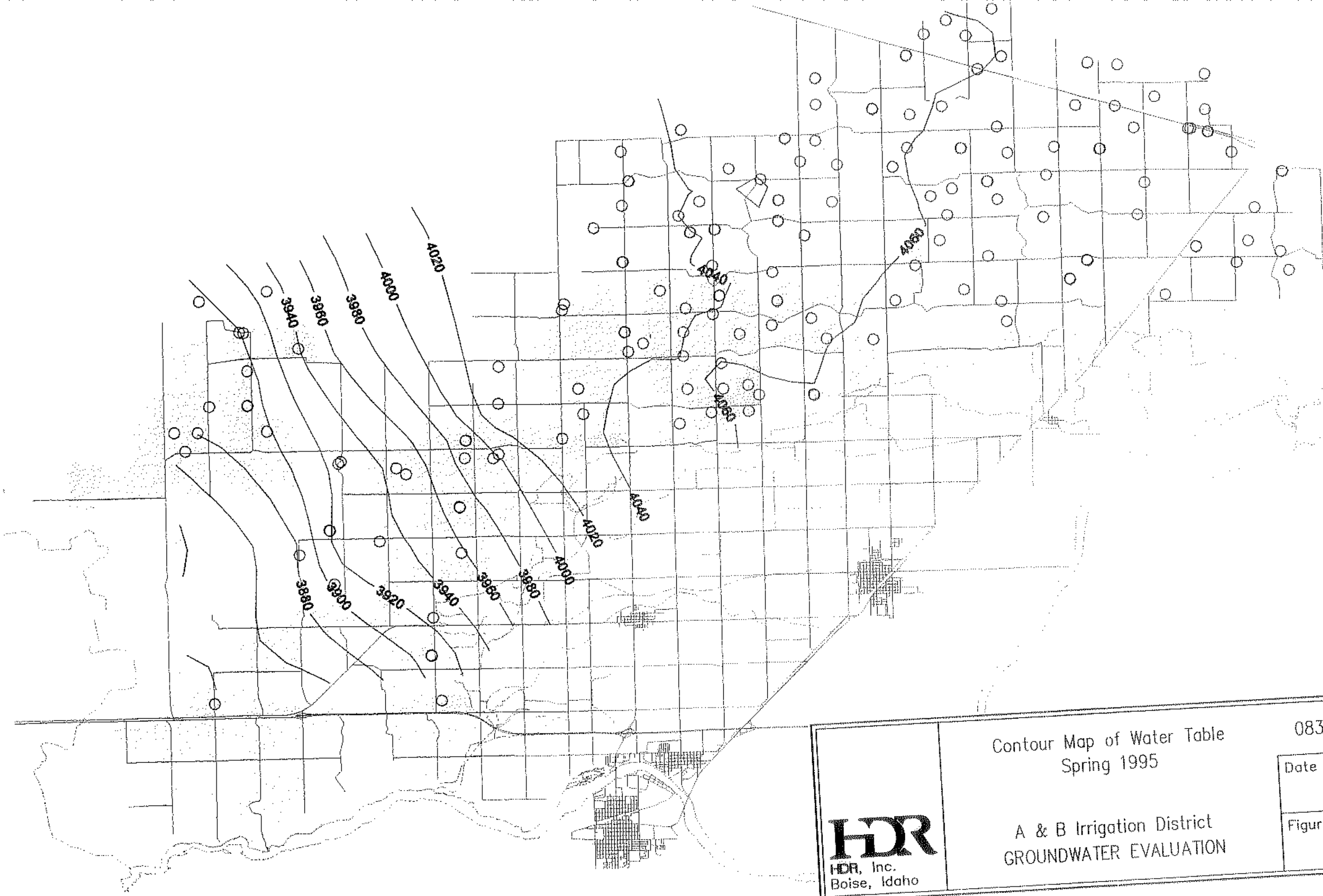



Figure 4. Hydrograph of Blue Lakes Spring, 1951 to 1993




| | | |
|---|---|---|
| HDR, Inc. Boise, Idaho | Contour Map of Water Table<br>Spring 1960<br><br>A & B Irrigation District<br>GROUNDWATER EVALUATION | 083130-001-103<br>Date: February 1998<br>Figure: 5 |




HDR
HDR, Inc.
Boise, Idaho

Contour Map of Water Table
Spring 1995

A & B Irrigation District
GROUNDWATER EVALUATION

083130-001-103

Date
February 1998

Figure
6


Contour Map of the Change in Water Table Between 1960 and 1995

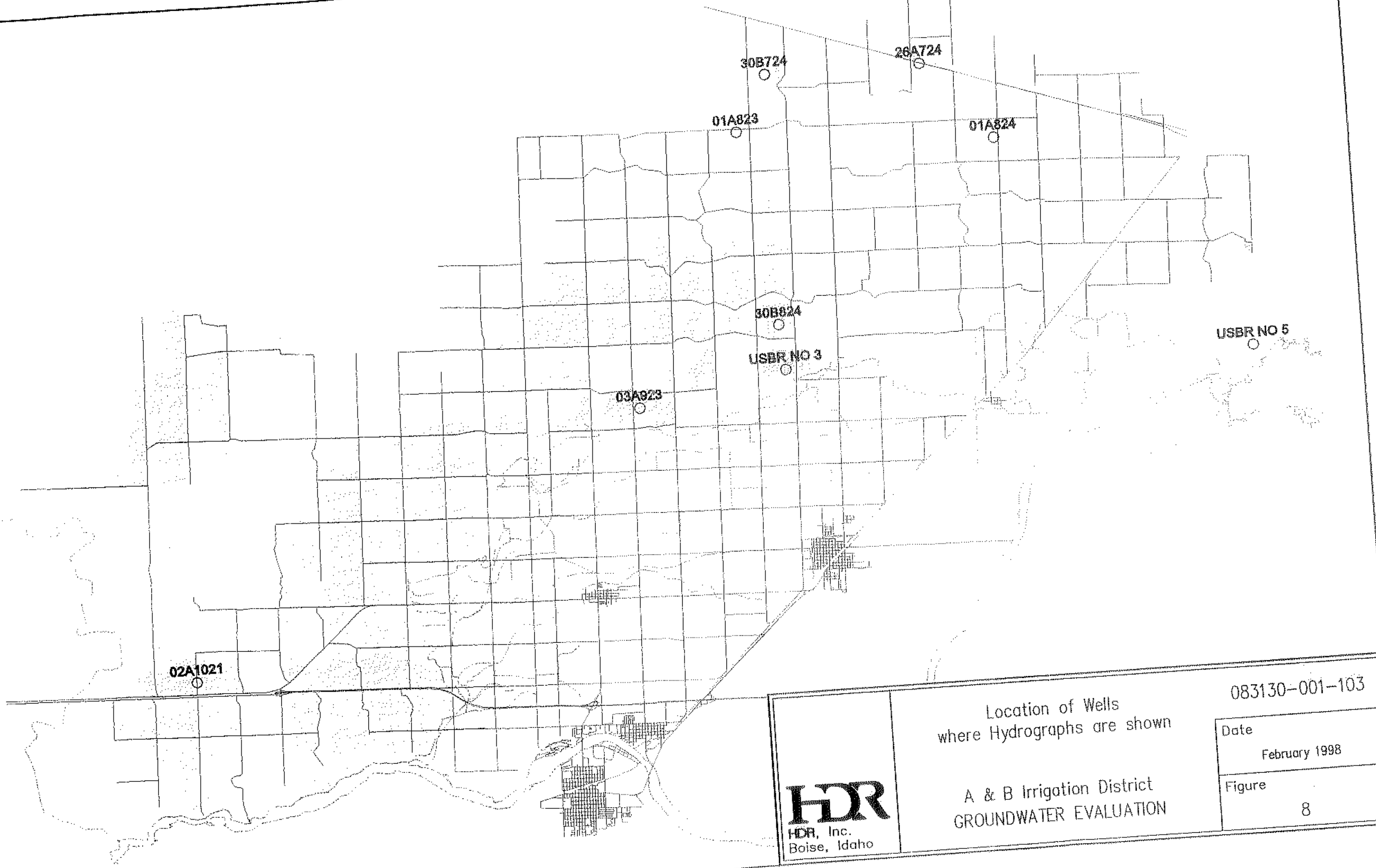
A & B Irrigation District
GROUNDWATER EVALUATION

HDR
HDR, Inc.
Boise, Idaho

083130-001-103

Date
February 1998

Figure
7




HDR, Inc.
Boise, Idaho

Location of Wells
where Hydrographs are shown

A & B Irrigation District
GROUNDWATER EVALUATION

083130-001-103

Date
February 1998

Figure
8

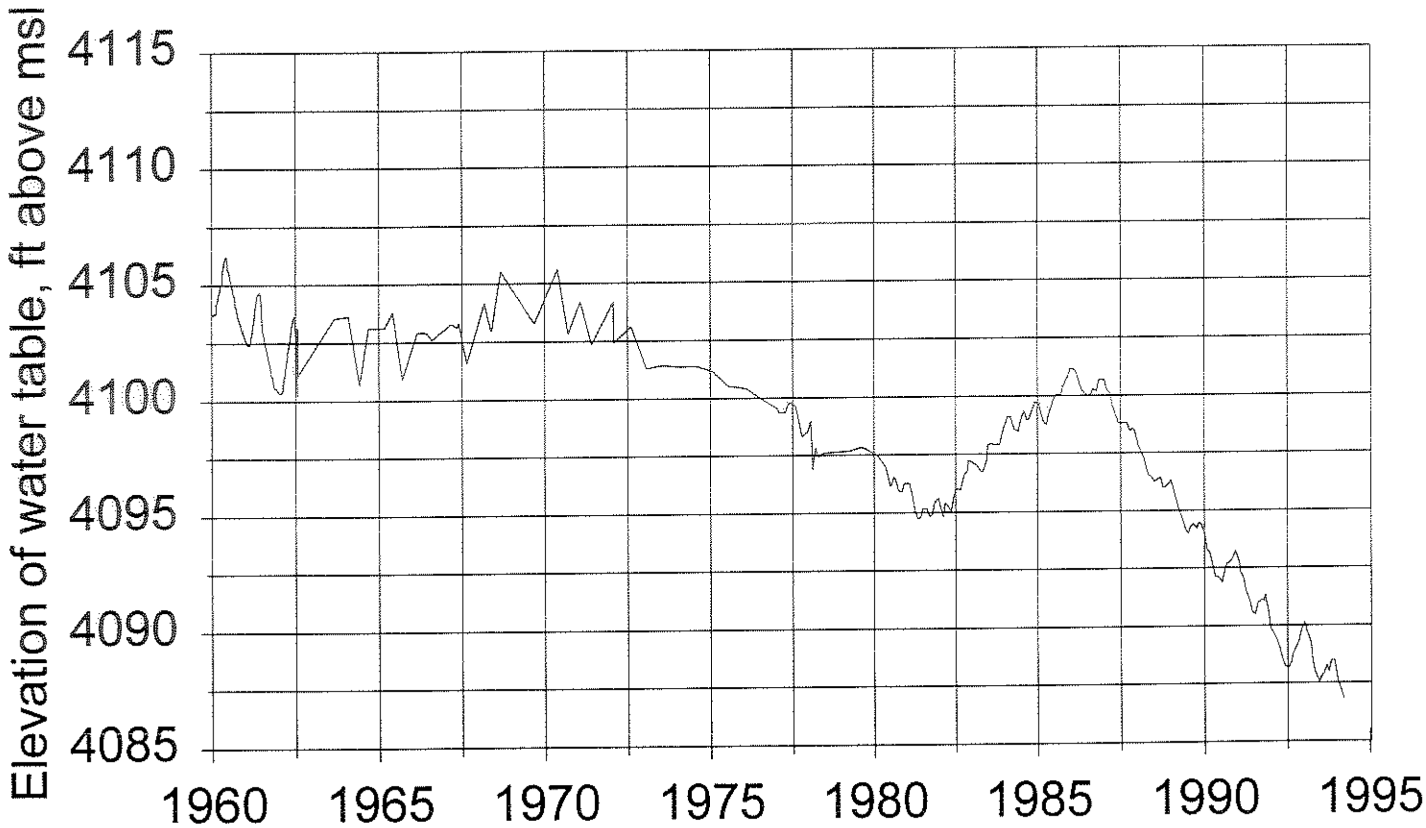



Figure 9. Hydrograph for USBR well USBR5

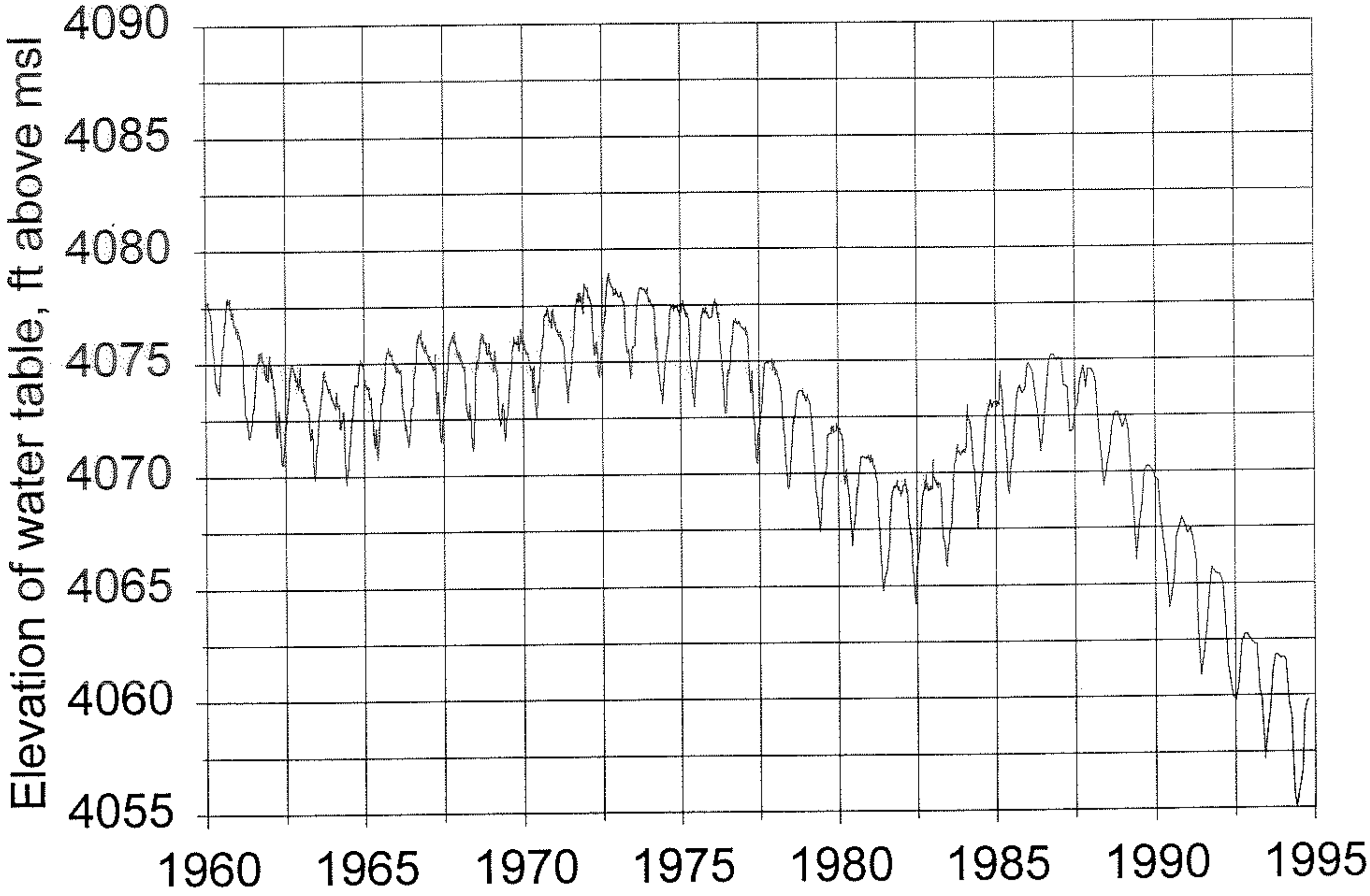



Figure 10. Hydrograph for USBR well USBR3

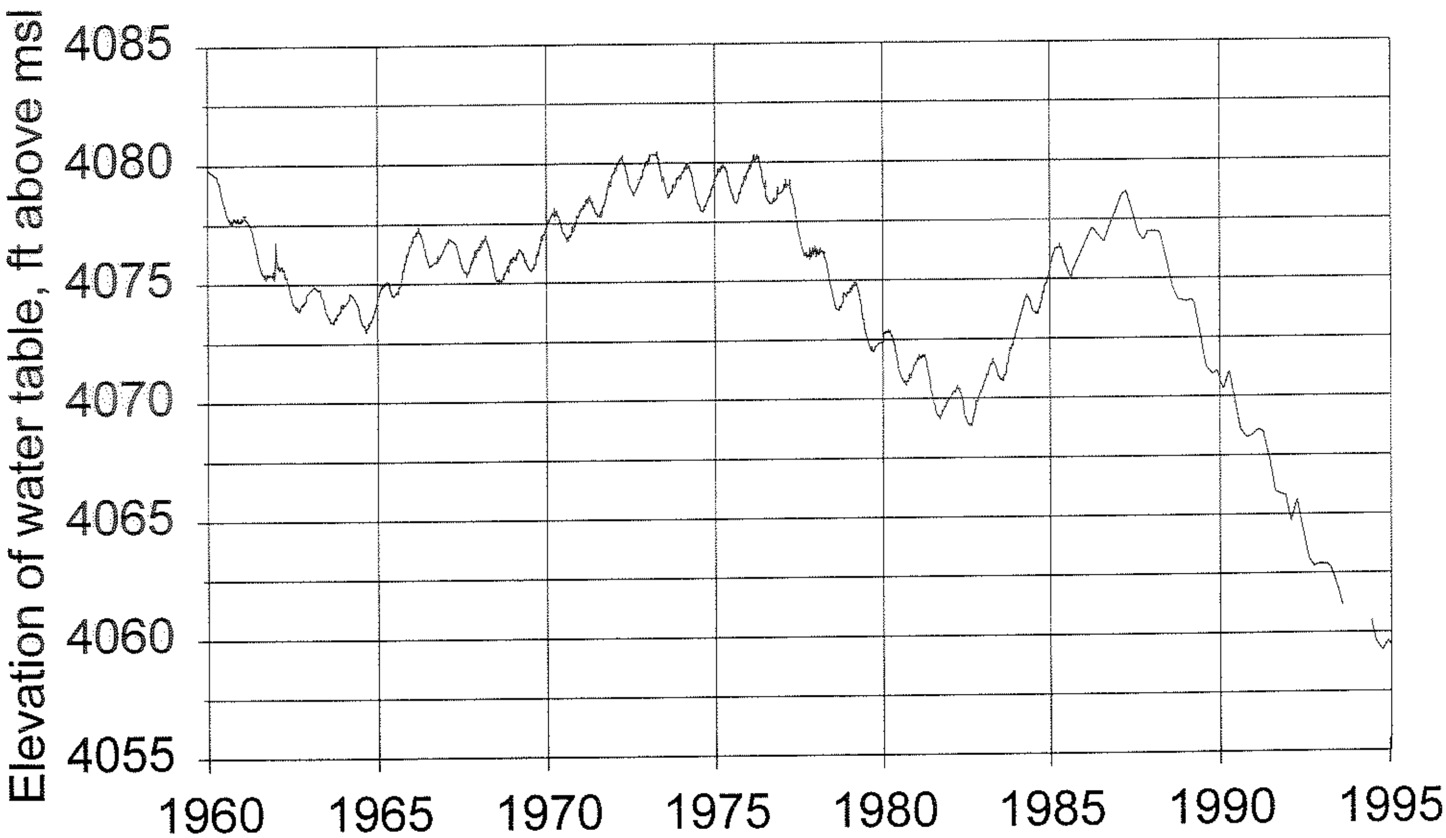



Figure 11. Hydrograph for USGS well 4S 24E 06BBC

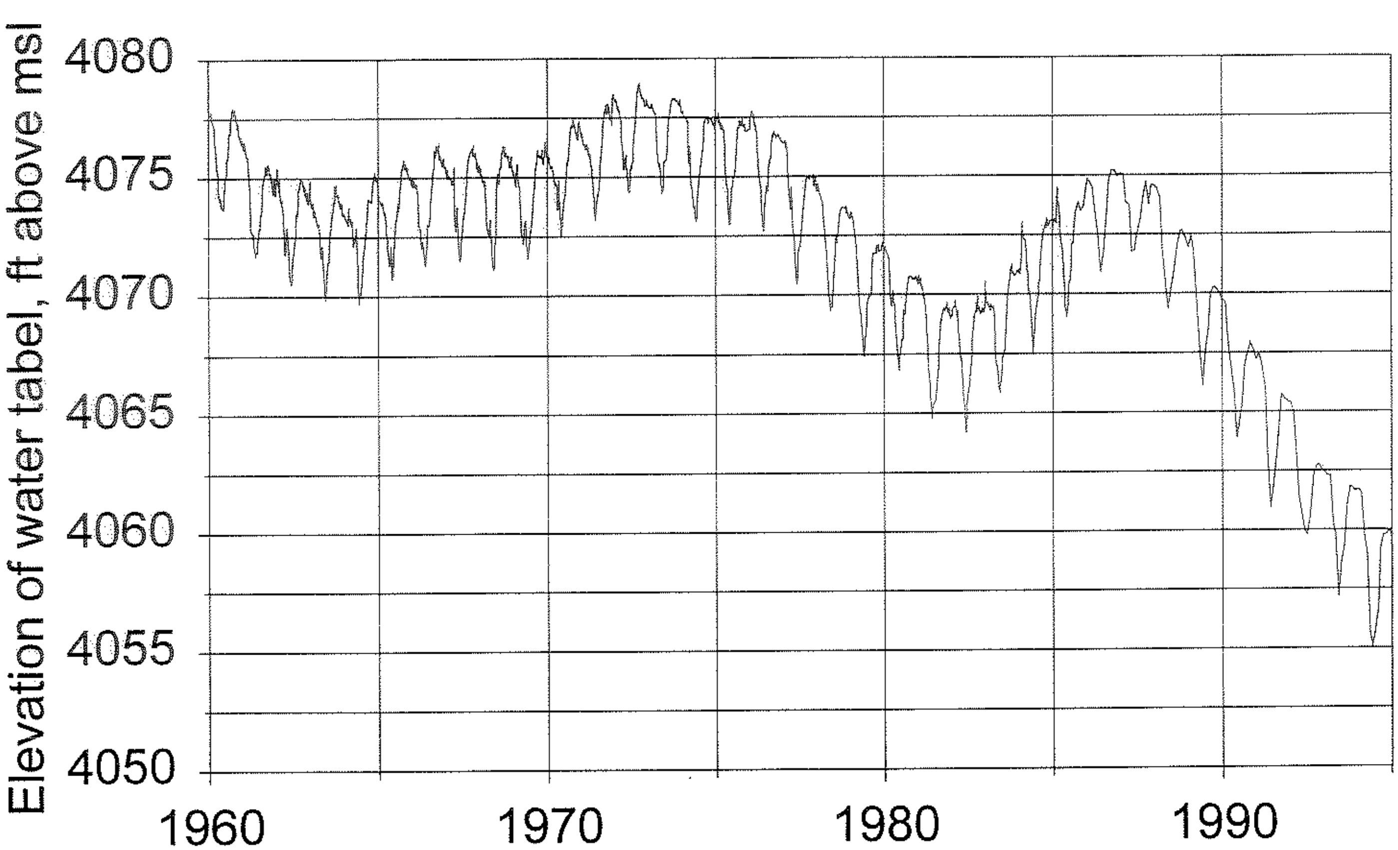



Figure 12. Hydrograph for USGS well 8S 24E 31DAC1

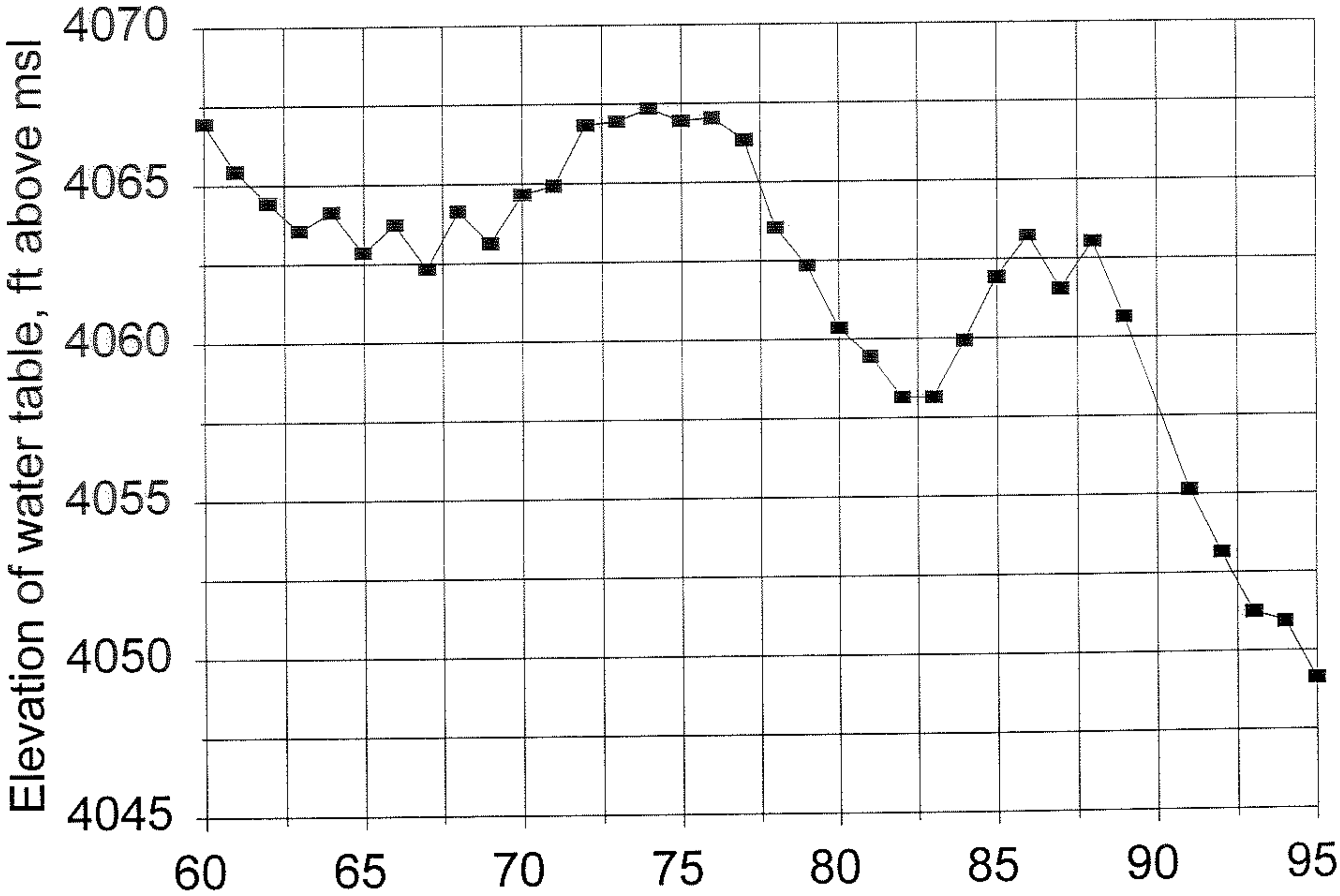



Figure 13. Hydrograph for A&B District well 30B724.

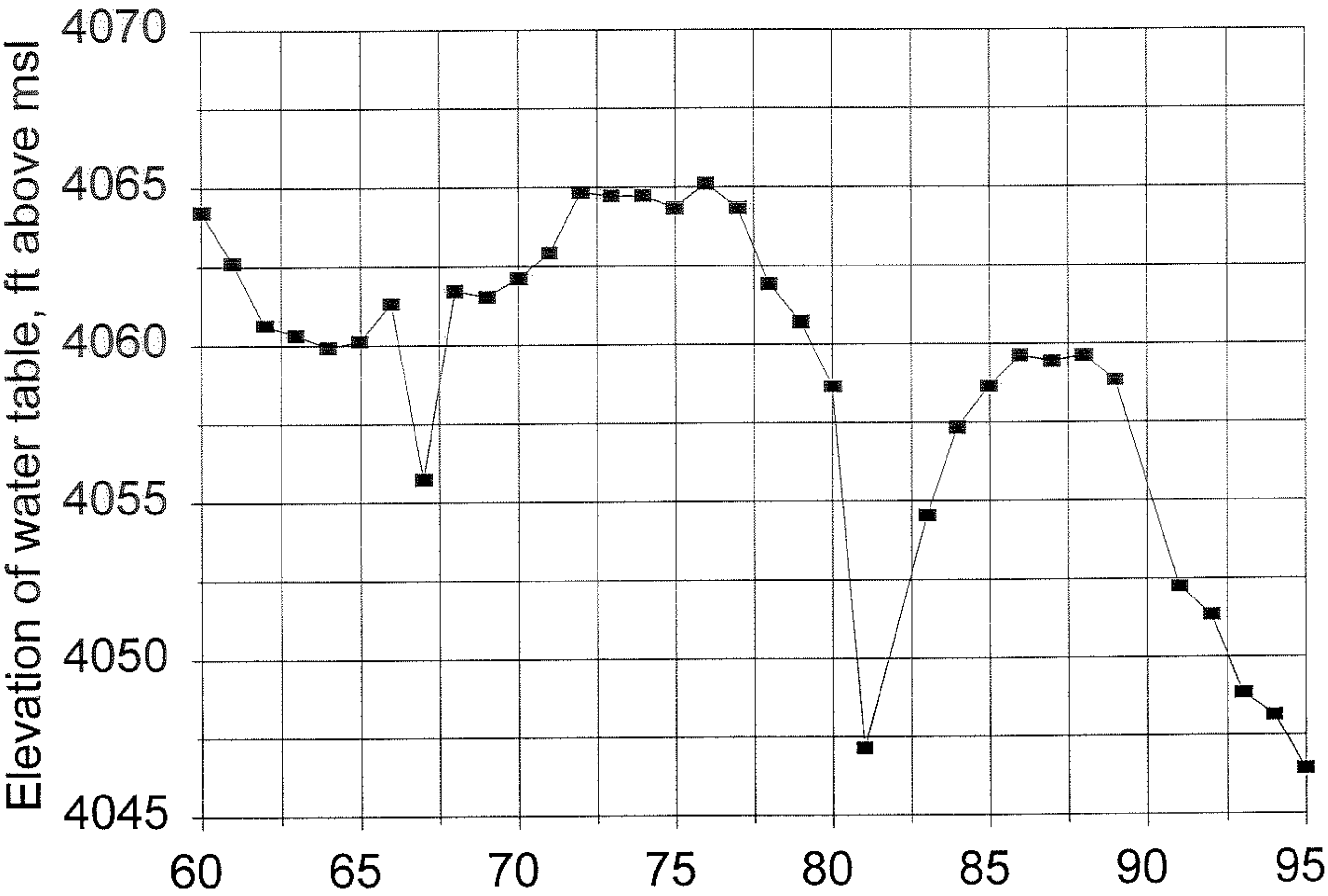



Figure 14. Hydrograph for A&B District well 01A823.

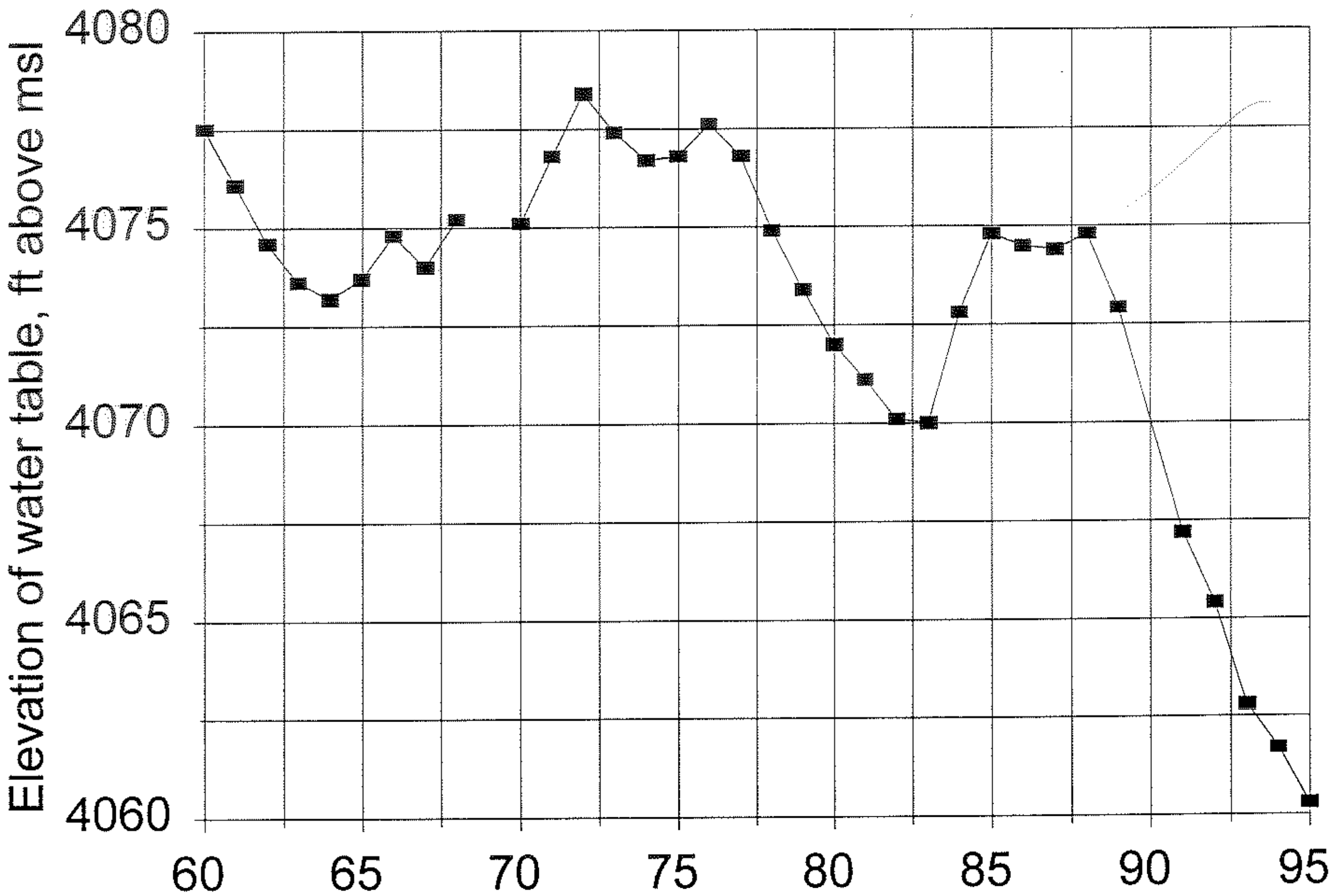


Figure 15. Hydrograph for A&B District well 30B824

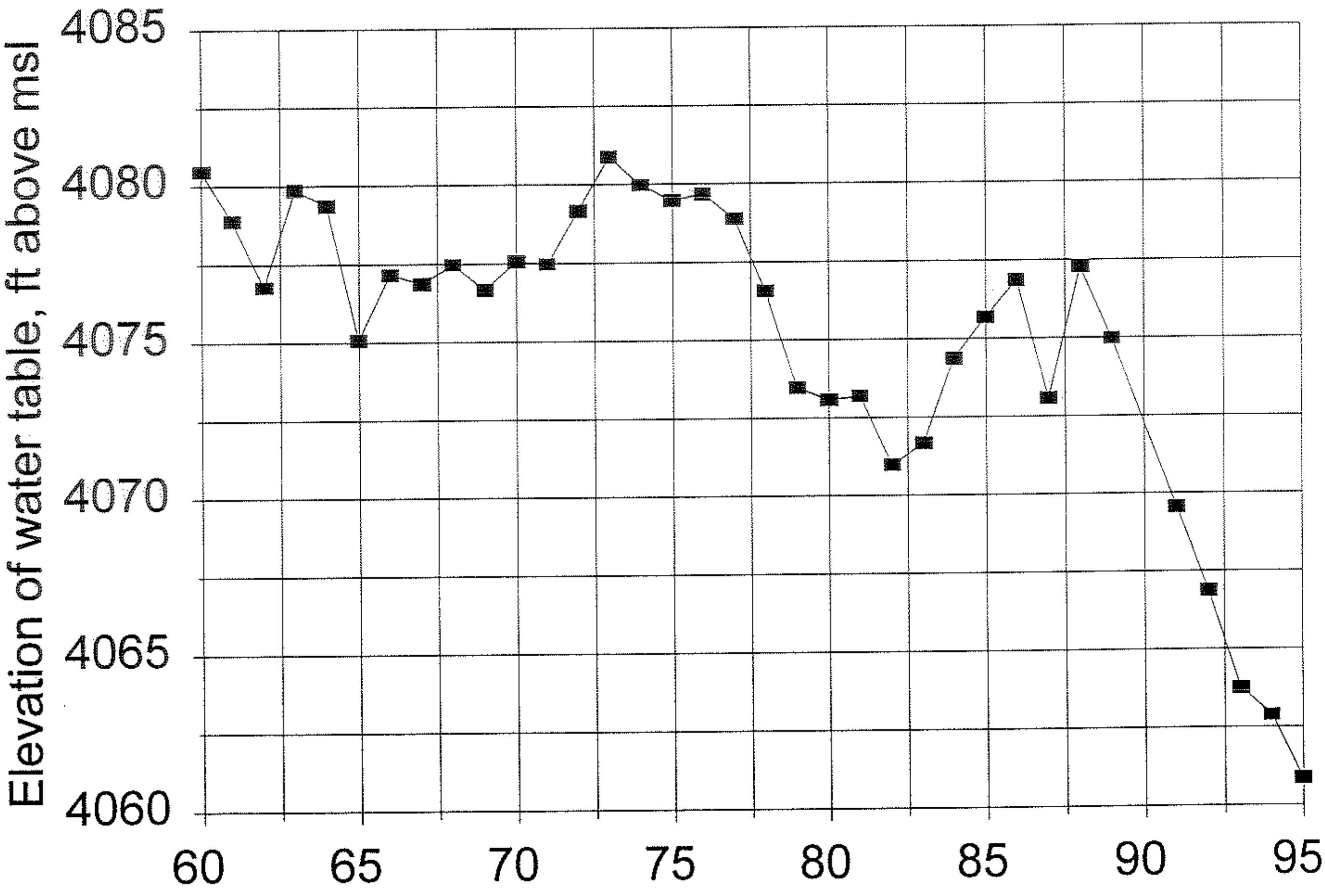


Figure 16. Hydrograph for A&B District well 26A724

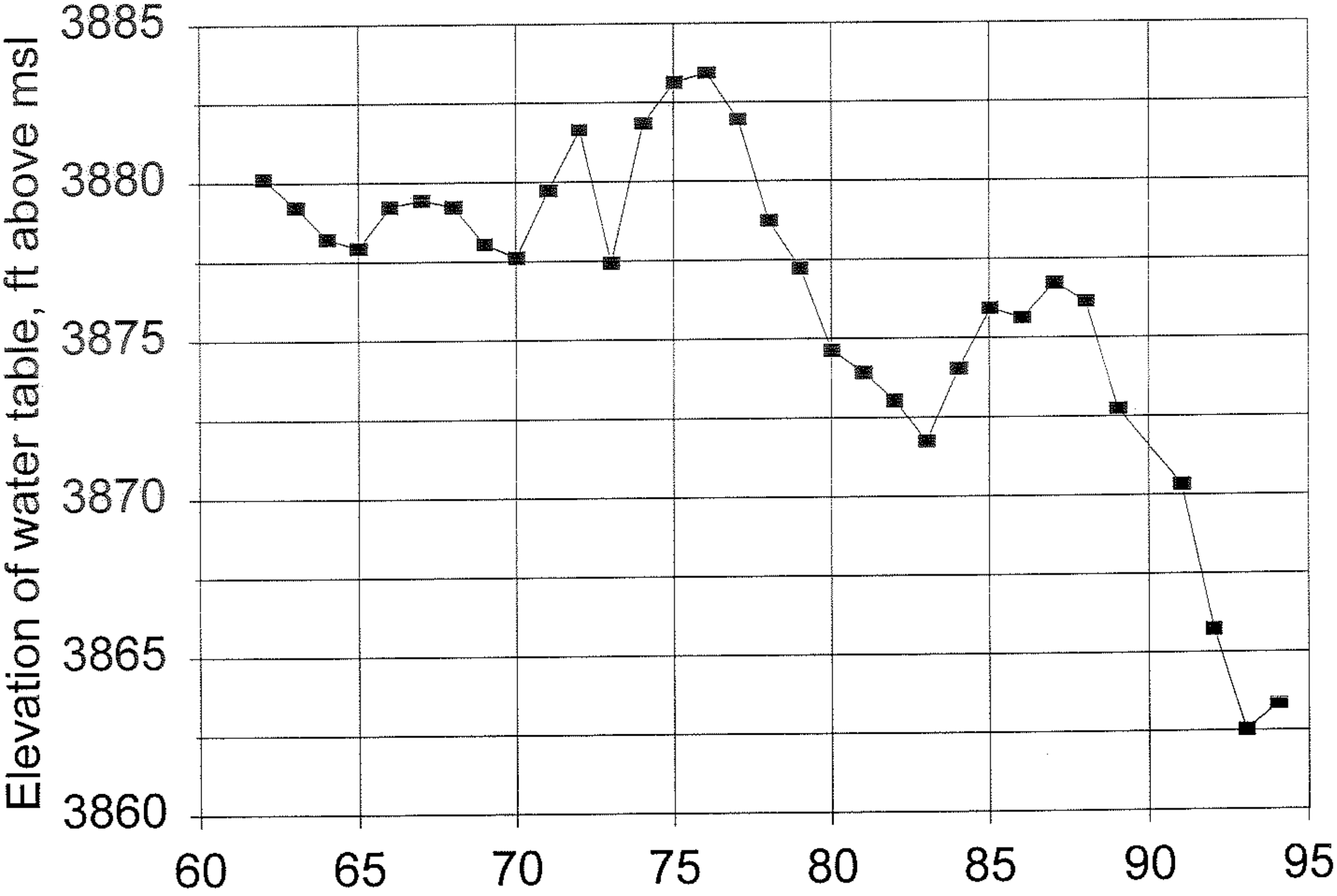



Figure 17. Hydrograph for A&B District well 02A1021

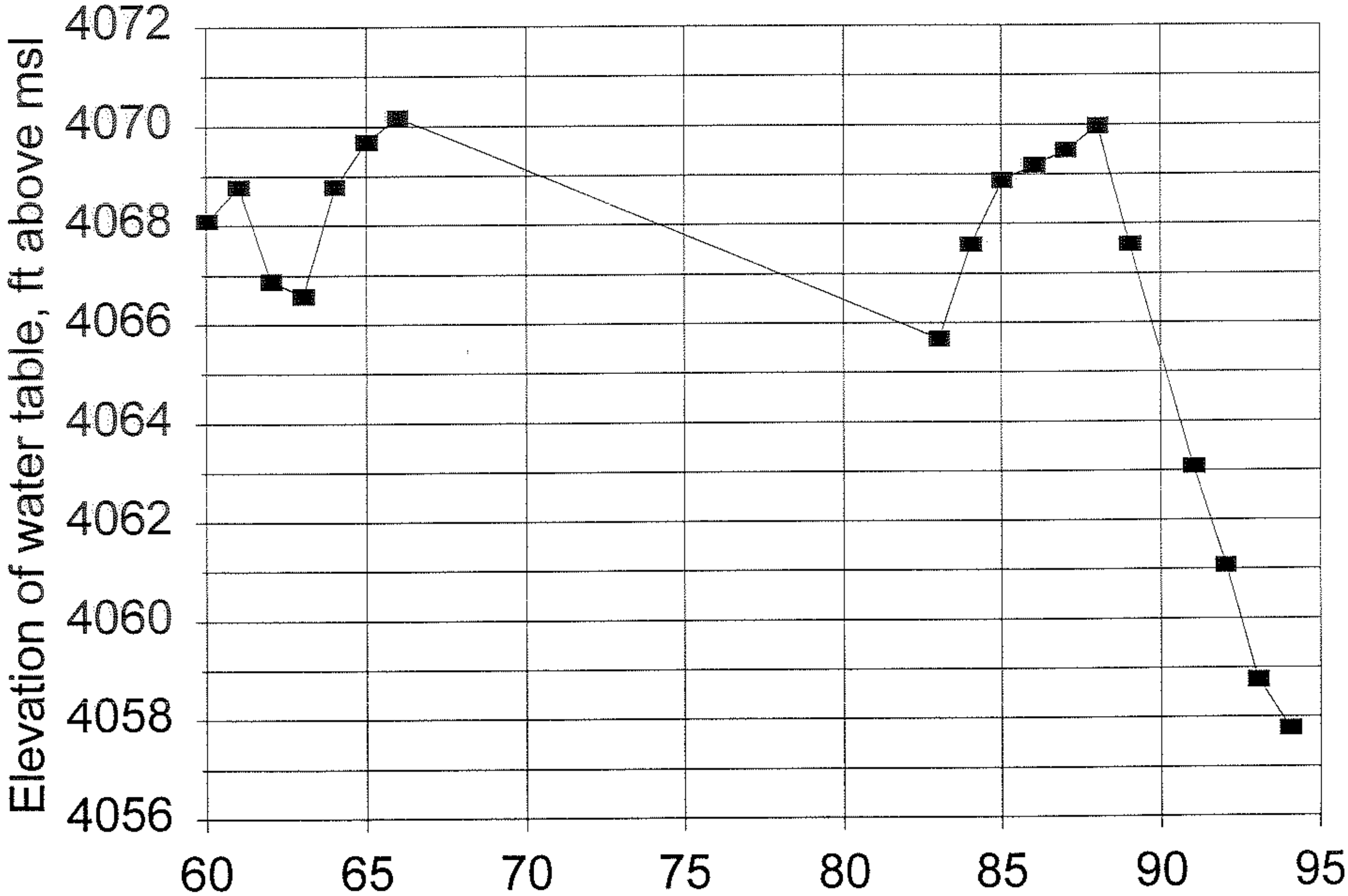



Figure 18. Hydrograph for A&B District well 03A923

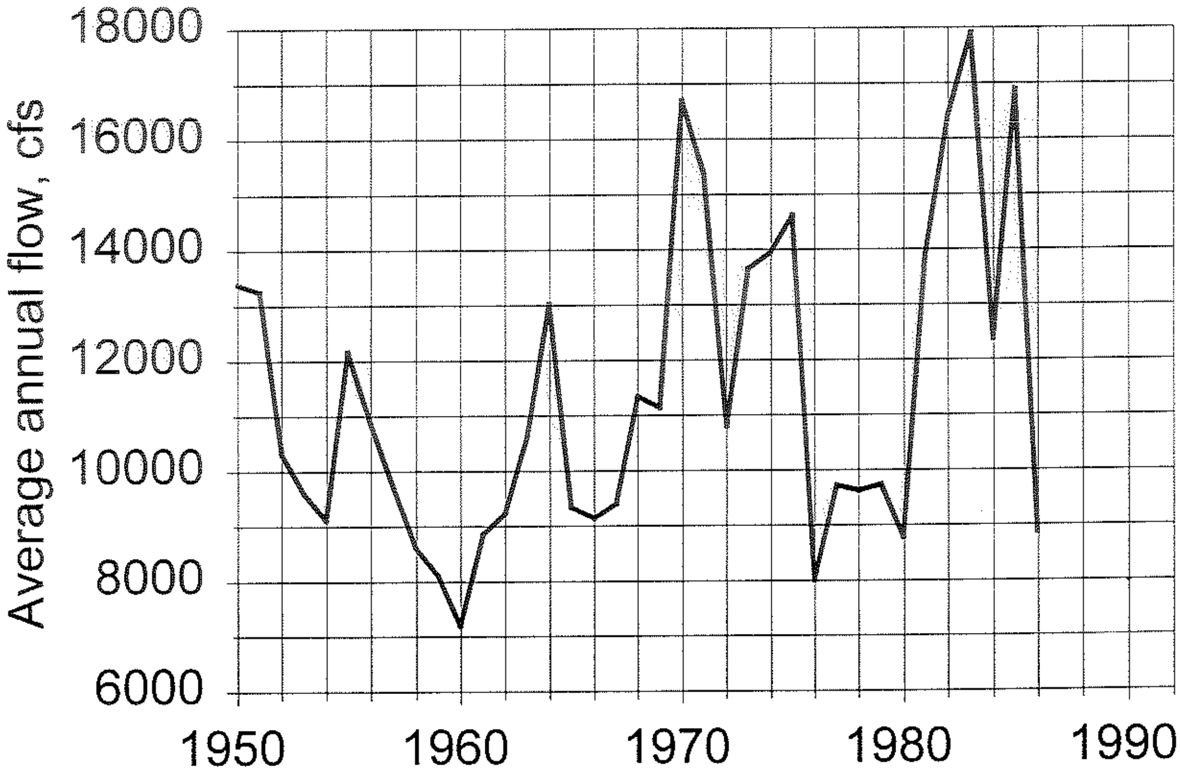



Figure 19. Snake River at King Hill, Idaho

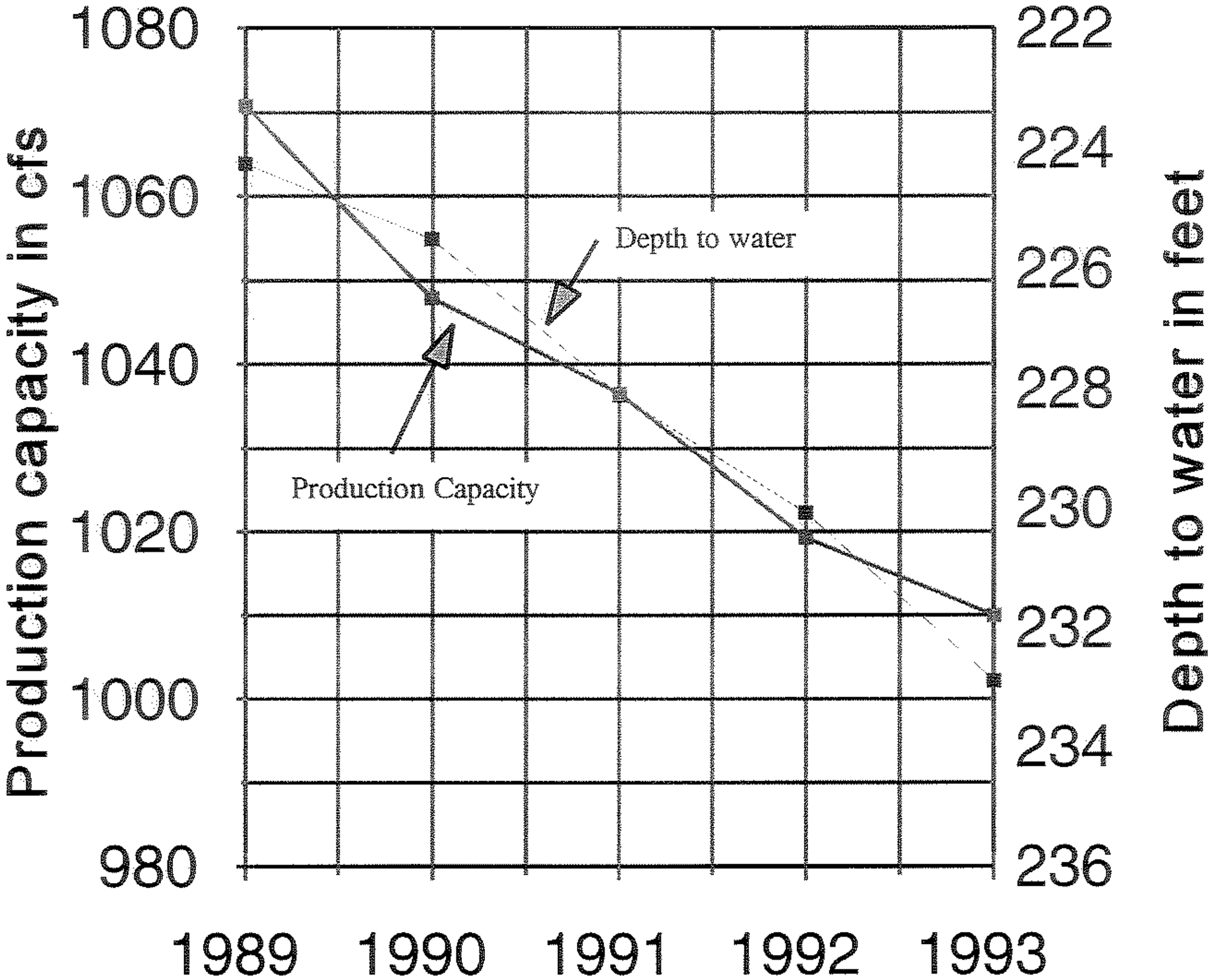



Figure 20 Well Production Capacity and Depth to Water from 1989 to 1994